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Research Article

Influence of the Electromagnetic Device Aqua 4D on Water Quality and Germination of Lettuce (*Lactuca sativa L.*)

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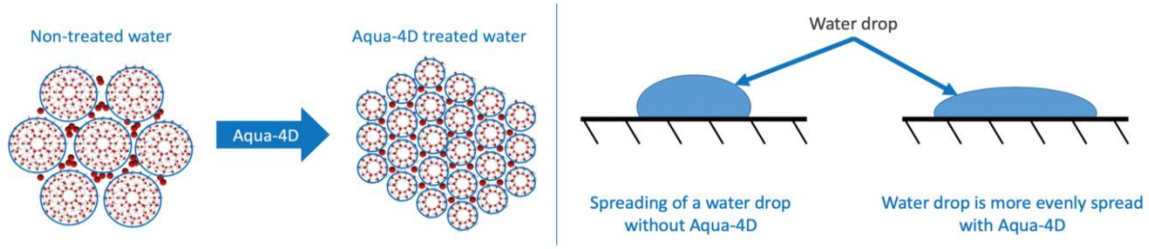
Abstract

Magnetic water technology has been widely studied and adopted in the field of agriculture in many countries (Europe, Russia, China, etc….), but in Morocco, the information available on the application of water loving in the agricultural sector is very limited. In order to show the effect of this technique on plant production under Moroccan conditions, an experiment was conducted in a culture chamber in the laboratory to study the response of the germination of lettuce to irrigate with magnetic and tap water under laboratory condition. The analysis of the results shows a persistent and highly significant improvement through an increase in the germination rate of the order of 45.83% and 55.5 %for treatment with magnetized water treated under the effect of the electromagnetic field Aqua 4D generated by the device for 80 min with renewal of magnetized water germination each 24h and 12 h relative to the control.

Keywords: *Electromagnetic water, lettuce, germination, Aqua 4D, electromagnetic fields, magnetized water.*

Graphical Abstract



1. Introduction

Water scarcity is expected to increase with rising global temperatures due to climate change. Increased international cooperation is needed to encourage the rational use of water and support treatment technologies in developing countries.

In Morocco, the scarcity of water resources and their unequal distribution presents a major risk, especially under the demographic growth and the increasing demand in the field of agriculture, industry and drinking water.

The majority of irrigation water in the arid and semi-arid zone in Morocco is of underground origin. The waters of groundwater are frequently salted with a salinity that exceeds 3g/l; toovercome this problem, a new technique (AQUA4D) based on the Electromagnetic treatment of water. The creation of a magnetic field affects the physical structure of water without changing the chemical structure (Planet Horizons technologies).The effects of electromagnetic fields on water have been the subject of research by

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chemists, physicists and biologists (parsons, 1997).Smirnov (2003) states that water can act as a mediator between the magnetic field source and the plant because water as well as electromagnetic wave conductor can receive signals emitted by magnetic forces. These results are confirmed by pang (2008) who agreed that water at a magnetic field influences the physicochemical parameters of water at macroscopic and microscopic scales. Moreover, Cai (2009) explains these changes by the formation of hydrogen bonds.

However, the work of many authors such as (Chibowski, 2003, Alimi, 2006) have established the positive effects of magnetic fields against lime scale deposits in water pipes and appliances, this technique also promotes increased germination rate and plant growth (Shabrangi, 2009; Hozayn *et al.*, 2018; Hozayn and Ahmed. 2019 and Hozayn et. al., 2019). However, this magnetism technology can be applied in the field of agriculture by the direct application of the magnetic field to plant organs (such as seeds). (Florez, (2007) explains by the magnetization of irrigation water or the presence of paramagnetic properties in the chloroplast (Hozayn and Amira 2010). On the other hand, Taimourya *et al.* (2015) proved that the treatment of water by a static magnetic field to show positive effects on the production of cabbage (*Brassica oleracea*) by an increase of 30%. Elaoud *et al.* (2016) foumd that magnetized water has an effect on the yield of the melon culture. Waleed *et al.* (2013) reported that the magnetic field of 0.5 Tesla resulted in an increase in root length and weightA remarkable improvement induced by the magnetic treatment was consistent with the results of other studies on onion. Magnetic field application increased the germination rate and the percentage of sprouted seed treated compared to the unexposed in both cases (Florez, 2012). Radhakrishnan and Kumari, (2013) Baghel *et al.*, (2016)Rathod and Anand, (2016) suggest that the use of this static magnetic field may be useful in the relief of abiotic stress in vitro and in field conditions. Static magnetic treatment has caused a significant increase in the height, leaf area and dry weight of plants subjected to salt stress (Rathod and Anand, 2016, Baghel *et al.*, 2016, Kataria *et al.*, 2017), magnetized water has an influence on the physical properties of the soils (Elaoudet. al.,.2019 and Cheikh *et al.*, 2018) to prove that the magenetized water increases the germination rate of the lettuce seeds. In this context our objective is to study the influence of magnetized water on the germination of the lettuce.

2. Materiel and Method

1) Equipment and physical characterization of the Aqua 4D Tube F60 in vacuum

Aqua-4D (Fig.1) is a physical water treatment technology, based on the quantum and the electrodynamics' physics.

Aqua-4D (Fig.1) is a physical water treatment technology, based on the quantum and the electrodynamics' physics. The quantum physics indicate that water is a matter organized and structured, and not chaotic as one might think. Water and its components can adopt many different structures. Depending on the structure taken
By the water, the behavior of dissolved minerals and biological materials is different. For the electrodynamics physics, electromagnetic field acts on the structure of water, giving it properties that create a better dissolution and distribution of minerals in the water, a better water retention in the soil, and a better adsorption of minerals by plants, while it's not destroying the bacterial soil life and is promoting a balance between the different elements of the living soil.

The electromagnetic device Aqua 4D consists of two basic modules:

- An electronic box pre-programmed to generate electromagnetic signals (EM).
- Tubes especially designed for transmitting the EMF signal into the water.

Twenty liters of water is used in each test to fill a plastic tank containing the immersed pump (H=1.8m, Q=1200 Lt/hr.) as shown in Fig 1. The circulation of water was continuous for 160 minutes in each experiment. Tests are made every 10 minutes for the physical properties of pH. The pH is tested by the pH meter AD 1000 made by AQWA Company. The Water was continuous for 160 minutes in each experiment. Tests are made every 10 minutes for the physical properties of pH. The pH is tested by the pH meter AD 1000 made by AQWA Company.

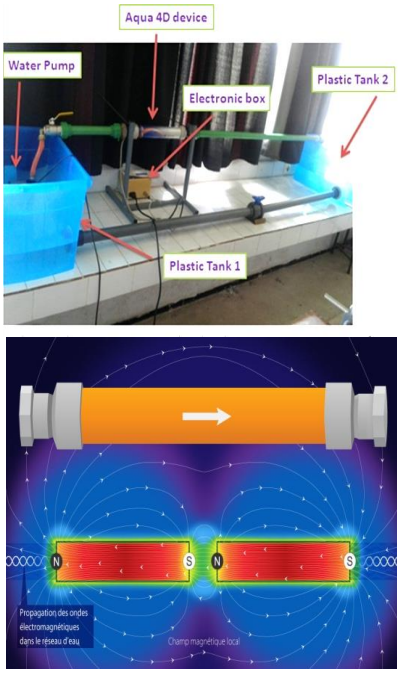

Fig.1: Equipments of Aqua-4D and Electromagnetic field generator

2) Chemical structure of the magnetized water

A substance is said to be magnetized when its constituent molecules or structural elements can be aligned in a definite direction by the influence of an external magnetic field. In a liquid or in a gas, this can only happen molecule that process and odd number of electrons. Water, H_2O, contains 10 electrons, so it is not attracted to or oriented by a magnet.

In fact, water, like most molecules, is diamagnetic; it is actually repelled by a magnet, although so weakly those sensitive instruments are needed to observe this effect. The Fig. 4 shows structural group of water molecules. Fig.(6) shows water molecules which consisted of one oxygen molecule and two hydrogen molecules bonded as an isolated triangle with its upper angle is 105º. Generally, when water is subjected to a magnetic field, the water molecules will arrange in one direction as shown in Fig. (6). This mode of arrangement is caused by relaxation bonds, then the bond angle decreases to less than 105º (Chibowski *et al.*1995), leading to a decrease in the consolidation degree between water molecules, and increase in size of molecules. For these reasons, the viscosity of magnetic water is less than viscosity of normal water. This change in water molecules composite causes a change in permeability pressure, surface tension, pH and electric conduction (Chibowski *et al.*1995).

The figures below show the theoretical arrangements of the hydrogen bonds before and after the treatment with the electromagnetic field.

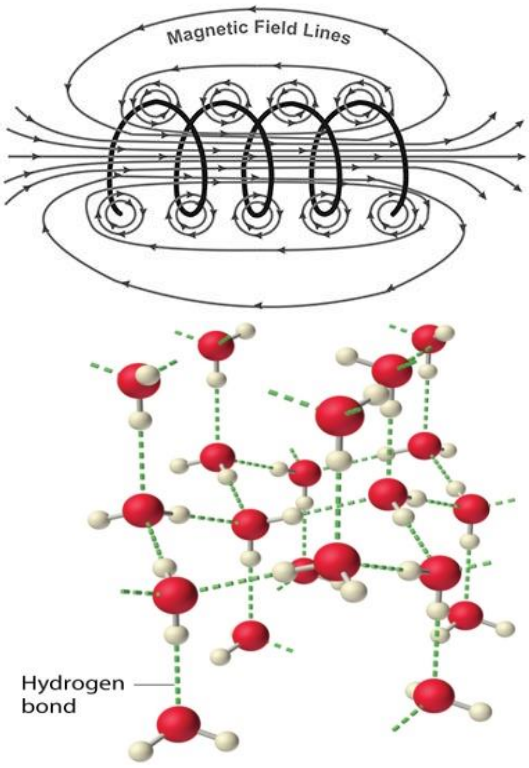

Fig.2: Solenoid magnetic field lines of Aqua-4D and Structural groups of water

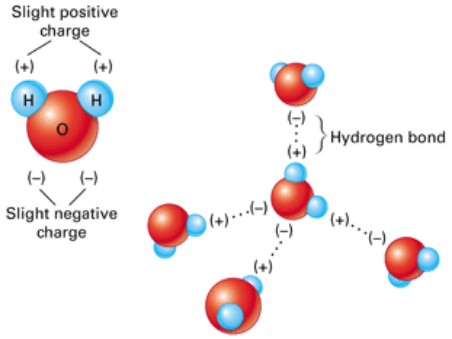

Fig.4: Water molecule and hydrogen bonds

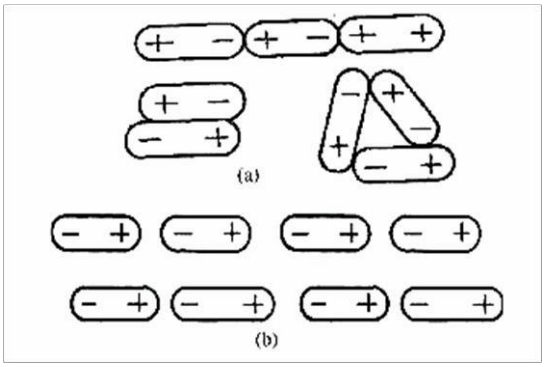

Fig.3: Dipole effect of magnetic field on water molecules: (a) is stable water clusters, and (b) is water molecules after passing through a magnetic field (McMahon, 2009)

3) Germination of Lettus (Lactuca sativa L.) Seeds

Studies and monitoring of water magnetization and germination were carried out at the Laboratory of Condensed Matter Physics at the Faculty of Sciences El-Jadida Morocco. Germination tests were carried out to study the effect of electromagnetic fields generated by the Aqua4D device on the germination of lettuce seeds with tap water. The test was performed at an ambient temperature of 26 ± 2ºC. Seeds of uniform size and shape without visible defects are used.

The tests are carried out with three types of water, **DW**: distilled water, **TW**: tap water and **MW**: magnetized water has different magnetization time ($\mathbf{t_m}$).

In this work, the Aqua 4D electromagnetic device is mounted on an experimental system support during the water circulates in a closed loop for 20min, 40min, 60min, and 80min to obtain water magnetized by an electromagnetic field (Fig.1).

4) Seed germination

Eighteen Petri dishes used for each test (three treated with MW t_m=80min , three treated with MW t_m=60min, three treated with MW t_m=40min , three treated with MW t_m=20min, three treated with tap water and three treated with distilled water), each containing ten seeds of lettuce for each test during the germination period estimated at four days (Fig.4).

Fig.4 Magnetic treatment on germination of lettuce seeds for each type of treatment.

For a statistical study we used twelve Petri dishes used for each test (quay treated with magnetized water, four with tap water and four with distilled water), each containing ten lettuce seeds for each test. Each test during the germination period estimated at four days (Fig.4).

3. Results and Discussion

Electromagnetic field effect on the pH of tap water at different speeds

The experience has been repeated many times. The results were presented in Fig.5.

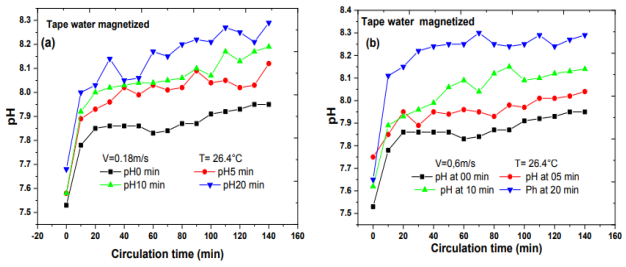

Fig.5:(a ,b) Changes in pH of tap water caused by magnetization during 5 min,10 min&20 min vs. Time, at T=26.4 °C, flow rate V=0.18m/s ,V=0.6m/s respectively (pH at 0min untreated)

1) Germination test with magnetized water renewed every 24 h at tm = 80 min

The results show that the germination rate was higher for seeds treated with magnetized water renewed every 24 h at tm = 80 min. The beginning of germination occurred faster (Fig 6.)

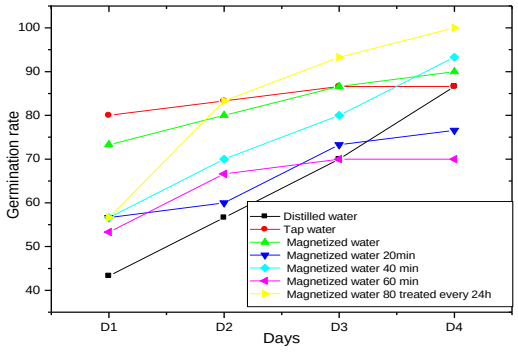

Fig.6 Germination rate of lettuce seeds treated with magnetized water tm = 20 min, tm = 40 min, tm = 60 min, tm = 80 min renewed every 24 h, distilled water and tap water.

The percentage of germination of the treated lettuce seeds by TW and DW is always lower than that corresponding to the water treated by the electromagnetic field MW which modifies the physicochemical properties of the water; the optimal external electromagnetic field can influence the rate and percentage of germination (Florez *et al.*, 2004). The germination rate in the first day varies by 50% after 4 days priming seeds in electromagnetically treated water this rate reaches a value of 87.5% with treatment with magnetic water renewed every 24 ha t_m = 80 min then that it varies from 40% to 60% for TW whereas this rate is from 27.5% to 60% for seeds treated with distilled water (Fig.6).

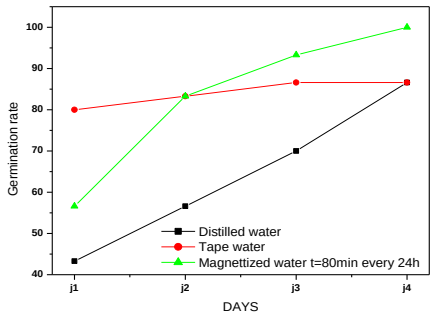

Fig.7 Germination rate of lettuce seeds treated with water TW, DW and magnetized water renewed every 24 hours at t = 80min

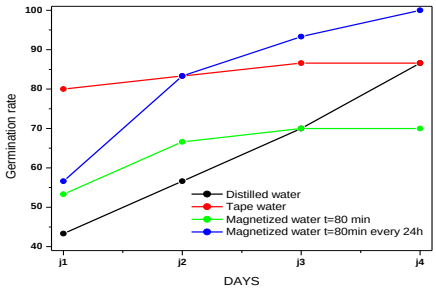

Fig.8 Germination rate of lettuce seeds treated with water TW, DW, magnetized water t=80min and magnetized water renewed every 24 hours at t = 80min

The response of the lettuce seeds to the loving water treated by the electromagnetic field depends on the magnetization time of the water, species and seed varieties (Fig. 7and 8).

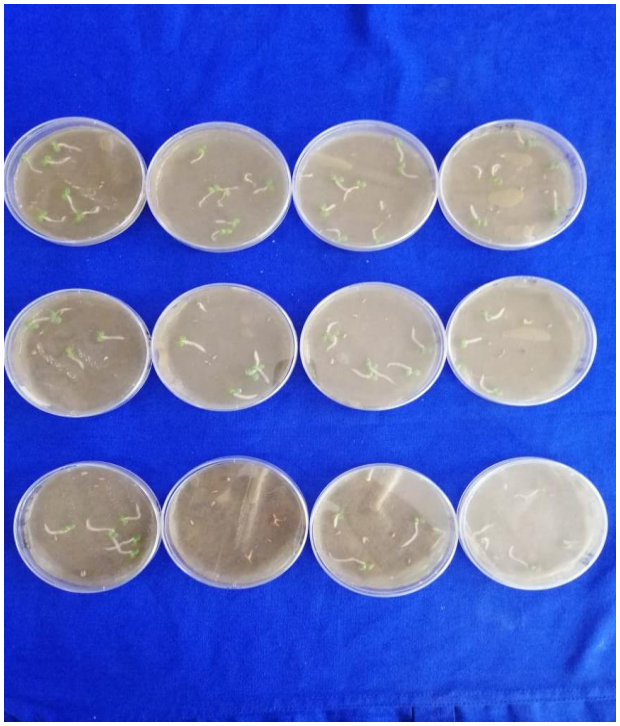

Fig. 9 Magnetic treatment on germination of lettuce seeds tm = 80min with renewal of MW every 24 h

Seed emergence counts were made with a progression of visible radicals through the integument. Data on germination rate and mean germination times were recorded up to 4 days.

The rate of germination is faster for seeds treated with magnetized water than untreated seed water. The longest roots and shoots were recorded with the water-treated seeds and the shorter stem and root were observed in the untreated seeds. The main objective of this study was to evaluate the effects of electromagnetic treatment on the germination of milk seeds.

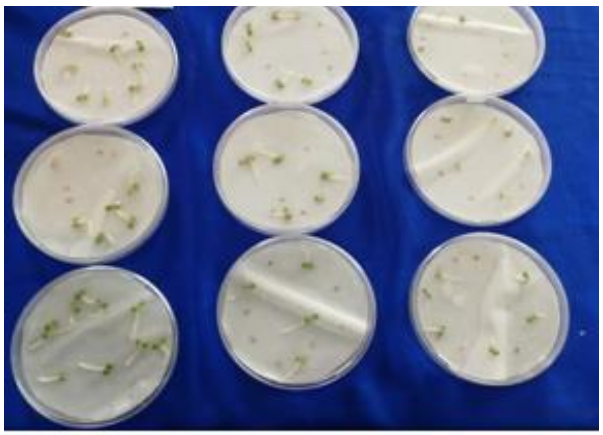

Fig.10. Effect of magnetized water on sprouts of lettuce

2) Germination test with magnetized water renewed every 12 h at tm = 80 min

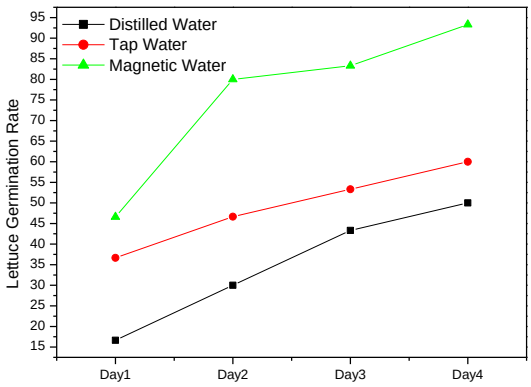

Fig.11. magnetic treatment on germination of lettuce seeds tm = 80min with renewal of MW every 12 h

The results show that the germination rate was higher for seeds treated with magnetized water renewed every 12h at tm = 80 min. The beginning of germination occurred faster (Fig.11).

The percentage of lettuce germination impregnated with water treated (MW) is greater than that impregnated with tap water (TW) and distilled water (DW), the electromagnetic field has an impact on the properties of water (Amiri *et al.*, 2006, Pang *et al.*, 2008), the rate of germination variation was influenced by the treatment of magnetized water with the electromagnetic field (Cheikh *et al.*, 2018). The percentage of germination reaches 46.6% after four days of germination of lettuce seeds. It reaches a value of 93.3% with treated water treatment (tm = 80min) (TW) renewed all the 12h. For tap water the germination rate goes from 36.6% to 60%. For disliqued water the percentage increases from 16.66% to 50% for lettuce grains (Fig.11).From the results obtained in fig.6 and 11 we can conclude that the percentage of germination is more important for lettuce seed treated with magnetized water for 80 min and renewed every 12h (93.3%) in second place comes ration rationing treats by the magnetized water for 80 min and renewed every 24h (87.5%) so the seed treated with magnetized water for 80 min with four day renewal is the lowest (70%), which proves that the magnetization of the water is weakened over time.

These results are in agreement with the work of (florez 2012) the application of a magnetic field increases the germination rate and the percentage of germ treatment compared to untreated plants. According to Cakmak *et al.*, (2010). Magnetic Field promotes the germination rate of bean and wheat seeds and, in addition, treated plants increased more rapidly than control plants (Cakmak *et al.*, 2010). Also, a positive effect of magnetic treatment on germination and emergence of bean cultivars has been confirmed; the emergence of seedlings is one of the most important factors in the production of pods per plant (Podlesny *et al.*, 2004). Many authors have found that

increased growth rate, enhanced protein synthesis, and increased root growth (Carbonell *et al.*, 2000, Martíne *et al.*, 2009, Florez *et al.*, 2007). Many studies have found a higher percentage of germination and greater plant growth (Kavi, 1983, Phirke *et al.*, 1996a, Hilal and Hilal, 2000, Moon and Chung, 2000).

Conclusion

The application of the electromagnetic field affects the physicochemical properties of water by increasing the pH.Also, the germination capacity and the germination rate of lettuce can be improved by the magnetized water produced by the Aqua 4D device.

In addition, the percentage of germination and the germination rate of the lettuce control grains are also lower than that of applied electromagnetic treatments. In conclusion, the use of the electromagnetic field could be an effective solution for improving the germination rate of lettuce

References

Parsons S. A., Judd S. J., Stephenson T., Udol S. et Wang B.L. (1997). Magnetically Augmented Water Treatment, Institution of Chemical Engineers, Vol 75, Part B,

May 1997.

Smirnov J.V. (2003). The Effect of a Specially Modified Electromagnetic Field on the Molecular Structure of Liquid Water. Global Quantec. Inc.(U.S.A): 122-125 Pang X.F. et Deng B. (2008). The Change of Macroscopic Features and Microscopic Structures of Water Under Influence of Magnetic Field. Physica B403: 3571-3577.https://doi.org/10.1016/j.physb.2008.05.032

CAI R., Yang H.; He J. et Zhu W. (2009). The Effects of Magnetic Fields on Water Molecular Hydrogen Bonds. Journal of Molecular Structure 938:15-19.https://doi.org/10.1016/j.molstruc.2009.08.037

Chibowski E., Hotysz L. et Szczes A. (2003). Adhesion of in Situ Precipitated Calcium Carbonate in the Presence and Absence of Magnetic Field in Quiescent Conditions on Different Solid Surfaces. Water Res. 37: 4685–4692.https://doi.org/10.1016/j.molstruc.2009.08.037

Alimi F., Tlili M., Amor M., Gabrielli C. et Maurin G. (2006). Influence of Magnetic Field on Calcium Carbonate Precipitation. Desalination206: 163-168. DOI: 10.1016/ j.desal. 2006.02.064

Shabrangi A. et Majd A. (2009). Effect of Magnetic Fields on Growth and Antioxidant Systems in Agricultural Plants. PIERS Proceedings, Beijing, (China), March, 23-27.

Florez M., Carbonell M.V. et Martinez E. (2007). Exposure of Maize Seeds to Stationary Magnetic Fields: Effects on Germination and Early Growth. Environ. Exp. Bot. 59:68–75.https://doi.org/10.1016/j.envexpbot.2005.10.006

Taimourya H., Bourarach E.H., ElHarif A., Hassanain N., Masmoudi L., Baamal L., Oussible M. (2015). Évaluation de la productivité du chou pommé (Brassica oleracea), sous l'effet de l'irrigation avec une eau traitée magnétiquement, dans la région de Casablanca (Maroc). Rev. Mar. Sci. Agron. Vét. 3 (2):27-36.

Elaoud A., Turki N., Ben Amor H., Jalel R., and Ben Salah N. (2016). Influence of the Magnetic Device on Water Quality and Production of Melon. International Journal of Current Engineering and Technology, Vol.6, No.6: 2256-2260. DOI: 10.14741/Ijcet/22774106/6.6.2016.48

Hozayn, M.,Abeer A. Ahmed;El-Saady A.A. and Abd El-Monem A.A(2019). Enhancement in germination, seedlingattributes and yields of alfalfa (*Medicagosativa* L.) under salinity stress using static magnetic field treatment. Eurasian Journal of Biosciences, 2019 - Volume 13 Issue 1, pp. 369-378.

Hozayn, M. and Abeer A. Ahmed (2019).Effect of tryptophan and ascorbicacid as magneto-priming on germination attributes of barley (*Hordeumvulgare*, L.) under salinity stress. Eurasian Journal of Biosciences, 2019 - Volume 13 Issue 1, pp. 245-251

Hozayn M., Amal A. A. EL-Mahdy and Zalama M.T. (2018). Magneto-priming for improving germination, seedling attributes and field performance of barley (*Hordeumvulgare*L.) under salinity stress. Middle East Journal of Agriculture Research, 7(3): 1006-1022.

Hozayn, M. and Amera M.S. Abd El-Qdoos(2010). Irrigation with magnetized water enhances growth, chemical constituent and yield of chickpea(*Cicer arietinum* L.).*Agriculture and Biology Journal of North America*, *1(4): 671 – 676.*

Waleed, A., Jabail, Riyadh, C.H., Abul, H. and Hussein, F. (2013). Effect of magnetic field on seed germination of Triticum aestivum. World Journal Agricultural Sciences. 1(5): 168-171.

Flórez M., Martínez E., Carbonell M V. (2012). Effect of Magnetic Field Treatment on Germination of Medicinal Plants Salvia officinalis L. and Calendula officinalis L. Polish Journal Environmental Studies, 57-63.

Radhakrishnan, R., Kumari, B.D.R. (2013). Protective role of pulsed magnetic field against

salt stress effects in soybean organ culture. Plant Biosystems. 147, 135–140. https://doi.org/10.1080/ 11263504. 2012.717543

Baghel, L., Kataria, S., Guruprasad, K. N. (2016). Static magnetic field treatment of seeds improves carbon and nitrogen metabolism under salinity stress in soybean. Bioelectromagnetics 37, 455– 470. DOI:10.1002/ bem.21988

Rathod, G.R., Anand, A. (2016). Effect of seed magnetopriming on growth, yield and Na/K ratio in wheat (Triticum aestivum L.) under salt stress. Indian J. Plant Physiol. 21, 15–22. DOI: 10.1007/s40502-015-0189-9

Kataria, S., Baghel, B., Guruprasad K.N. (2017). Pretreatment of seeds with static magnetic field improves germination and early growth characteristics under salt stress in maize and soybean. Biocatalysis and Agricultural Biotechnology. 10, 83-90.https://doi.org/10.1016/j.bcab.2017.02.010

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O. Cheikh, Anis Elaoud, H. Ben Amor et M. Hozayn (2018), « Effect of permanent magnetic

Field on the properties of static water and germination of cucumber seeds». International

Journal of Multidisciplinary and Current Research. Pp108-116 V6. doi.org/10.14741/ijmcr.v6i01.10916

Chibowski, E., Hołysz, L., 1995. Changes in zeta potential of TiO2 and CaCO3 suspensions treated with radiofrequency electric field as measured with Zeta Plus instrument. Colloid. Surf. A 105, 211e220.https://doi.org/10.1016/ 0927-7757(95)03321-1